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THE MUSCULAR STRENGTH OF COLLEGE WOMEN

WITH SOME CONSIDERATION OF ITS DISTRIBUTION:
PRELIMINARY PAPER

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The present world war has called women to tasks totally unsuited to the accepted standards of woman's physical strength and capacities. At the present time, therefore, when our nation needs to mobilize every particle of woman power as well as man power, it is well to determine with as much definiteness as possible what that power may be. In the case of woman particularly, it is useful to know whether these unprecedented demands on her strength and activities are liable to make her racially less efficient, and whether many of the handicaps are real or only traditional.

In hope of gaining more exact information concerning the muscular strength of woman, this study was undertaken.

Dr. Martin's method of testing muscular strength,¹ originally devised for the study of cases of anterior poliomyelitis, was used. Forty-five average healthy college women, most of whom had always been physically active, although, in the majority of the instances, not specially athletic, were studied.²

In the progress of this work, certain improvements in the manner of applying the spring balance method to adults were devised.

1. Martin, E. G., and Lovett, R. W.: A Method of Testing Muscular Strength in Infantile Paralysis, *THE JOURNAL A. M. A.*, Oct. 30, 1915, p. 1512. Lovett, R. W.: The Treatment of Infantile Paralysis, p. 152.

2. Miss Etta L. Paris and Miss Inezetta Holt of the Department of Physical Training for Women, Stanford University, have given invaluable assistance in making these tests.

The following groups of muscles both on the right and the left side of each woman were tested: pectorals, latissimus dorsi, anterior and posterior deltoids, forearm extensors and flexors, wrist extensors, thumb adductors, and either wrist flexors or finger flexors. The wrist flexion test was found by some of the women to cause lameness. The finger flexion was substituted in the later testing. These muscle groups were tested with the subject standing. The following tests were made in the horizontal position: dorsal flexion, inversion and eversion of foot, adduction and abduction of thigh, hip extension and flexion, knee extension and flexion.

Thus a full test included observations of thirty-six groups of muscles. Each test was repeated two or three times, thus insuring as accurate observation as possible by securing the maximum cooperation of the woman on whom the tests were made. The highest record correctly made was used in each case.

TABLE 1.—AVERAGE, MAXIMUM AND MINIMUM STRENGTHS
FACTORS OF FORTY-FIVE WOMEN ARRANGED
IN AGE GROUPS

Ages	16-20	20-25	25-35	35-56	All Ages
No. of cases	10	26	5	4	45
Average strength factor	21.5	23.8	23	20.8	22.5
Maximum strength factor	26.6	30.4	25.3	25.3	30.4
Minimum strength factor	18.4	19.3	18.7	16.6	16.6

These forty-five women were tested 120 times; there were ninety-five full tests and twenty-five partial tests. Every woman was tested from two to five times, and 3,576 muscle groups in the forty-five women were tested. Dr. Mosher made schematograms³ of all the women studied.

A convenient method of classifying the persons studied is in terms of "the strength factor," which is simply the figure obtained by dividing the total strength, as determined by the tests, by the weight. In Table 1 the strength factors for the entire group of cases are summarized.

In Table 2 the cases are grouped in accordance with their strength factors. A study of the table shows that the first group, which has the lowest average strength factor, 18.78, is made up of the tallest and heaviest women, with 50 per cent. of them overweight,

3. Mosher, C. D.: The Schematogram in School and Society, 1, May, 1915.

the average overweight being 30.1 pounds. In this group, also, three of the eight women are immature physically though not sexually, and six, or 75 per cent., show a marked lack of coordination.

The third group has an average strength factor of 26.77, which approaches the strength factor of the group of athletic college men. This group of women is especially remarkable because it is made up almost uniformly of the most perfect feminine type. Two cases (28 and 42), which fall somewhat below this standard, will be discussed later. Members of the third group of women are, on the average, shorter and more compactly built, and lighter in weight than members of either of the other two groups.

We find here, with only two exceptions, the women with the highest degree of coordination. The most

TABLE 2.—FORTY-FIVE WOMEN ARRANGED IN GROUPS ACCORDING TO STRENGTH FACTOR

Number of cases	Strength Factor	Strength Factor	Strength Factor	Strength Factor
		20 and Below	Above 20 and Less than 25	25 and Over
8		26		11
Strength Factor:				
Average	18.78	22.3	26.77	
Maximum	20	24.6	30.4	
Minimum	16.6	20.3	25	
Total Strength:				
Average	2,789	2,960	3,513	
Maximum	3,220	3,330	4,130	
Minimum	2,320	2,565	3,060	
Average age	27	23.5	23.9 ₁₂	
Maximum age	56	53.3	42.4 ₁₂	
Minimum age	18	18	16.2 ₁₂	
Average height	65	64.5	63.7	
Maximum height	68.9	67.7	66.4	
Minimum height	62	60.2	59.6	
Average weight	148.9	133.6	131.6	
Maximum weight	170.8	154.5	165.5	
Minimum weight	119.8	116.4	112.9	
Overweight (5 pounds)	(4)	(12)	(5)	
Average	30.1	15.78	15.5	
Maximum	39.5	32.5	39.5	
Minimum	11	5.3	5.4	
Underweight (5 pounds)		(5)	(2)	
Average	*	11.4	9.1	
Maximum	*	17.8	13.0	
Minimum	*	5.2	5.3	

* None over 5 pounds.

striking fact in connection with the women of this group is, perhaps, their history in regard to exercise. Without exception, they have always been physically active, playing with brothers and boy cousins without distinction of sex, sharing the same games and having the same activities.

Case 28, with a strength factor of 28.4, and Case 42, with a strength factor of 25.5, also rather immature,

fall somewhat below the high average standard of type in this group, although they both, in regard to the secondary sexual characters, and functionally, are normal women. Both belong to the tall, lean type, though they lack the poise and balance found so uniformly in this group. They are precipitate in action and show a lesser degree of coordination than the other members of their group.

Case 36, the oldest woman in the group, aged $42\frac{1}{2}$, is married, has borne three children, and has a strength factor of 25.3. She said, "I have played running games and a little football, climbed trees, ridden horseback, played tennis in college, and had four years of gymnastics. When there was anything to do, such as moving a piano or a trunk, it never occurred to me to call a man. I did whatever there was to do. I have never worn a corset, and my clothes have been loose and supported. When fashion demanded three petticoats, I wore one." In this middle period of life, she has retained her youthfulness and sparkle to an unusual degree, and is intellectually brilliant.

Case 41, the youngest girl in this group, aged $16\frac{1}{2}$, has a strength factor of 26.6. She is a charming young girl, very feminine in type, an unusually good tennis player, is musical, and is intellectually of great promise. This case is of special interest since a record was made of her brother, who is only fourteen months older, and whose strength factor was found to be 26.4, a matter of 0.2 less than his sister's. The two were brought up with the same occupations and physical activities until the girl was 12 years old, when she was graduated from her overalls into skirts and into some of the conventional physical limitations of women.

The second group is composed of women in whom the same causes are operative as in the first and the third group. For lack of space, the discussion of this group will be postponed to a later paper.

Four married women ranging in age from 34 to 56 years gave an average strength factor of 20.8. The maximum strength factor in this group is 25.3, which is considerably above the average of the whole group of forty-five women, and is exceeded by only five others in the whole series of women studied. The four women of this group have borne thirteen children.

A general comparison of the series of forty-five college women with the series of athletic college men by Dr. Martin and Mr. Rich,⁴ yields some suggestive results. Let us consider briefly the strength of the different muscle groups.

The pectoral muscles are commonly relatively stronger in man than in woman, the average percentage of total strength being 2.35 in man, and 2.1 in woman. Twelve women have equaled or exceeded the average of the men. Case 35 from the second group, a married woman who has borne two children, has in her pectorals 2.52 per cent. of her total strength. This difference between men and women, which is apparently not one of sex, may be explained as due to the difference in use. Constant ball playing, punching and thrusting make up a very large part of the boy's exercise. His clothing does not limit the use of the pectoral muscles, as do a woman's waist, brassière, etc. Moreover, although dress and convention have discouraged the use of the pectoral muscles in woman, their weakness is a distinct racial disadvantage. If the pectoral muscles were well developed in the woman, we should find fewer pendulous breasts in the young girl, as well as in the older woman.

The latissimus dorsi is better developed in woman than in man, contributing 1.65 per cent. of the total strength of woman and only 1.45 per cent. in man. The buttoning of women's waists and skirts in the back brings this group of muscles into constant use from childhood, while the boy's clothes are always more conveniently buttoned on the side or in front.

The anterior and posterior deltoids in woman create from 2.45 to 1.80 per cent. of her total strength, while in man they create only from 2.1 to 1.35 per cent. of his total strength. This difference again is readily explained as due to difference in use, that is, to woman's constant practice of putting up her hair. It is common knowledge that the girl with heavy hair cries with fatigue day after day as she is taught this conventionally necessary use of her muscles. An athletic woman not considered in this series of observations tells me that the fatigue of putting up her heavy hair on top of her head is still so great that she has been forced to dress it low after repeated attempts.

4. Rich: To be published.

There is no occasion for a habitual use of the deltoids among men, and, furthermore, their heavy coats tend to limit the freedom of action of the deltoids.

Forearm extensions and flexions are better developed in man than in woman, making from 1.5 to 2.35 per cent. of man's total strength and only from 1.3 to 1.85 per cent. of woman's. Here again woman's close-fitting waists and sleeves and the conventional view of her physical delicacy, which would protect her from lifting all heavy weights, might at least partially explain this difference.

Wrist extension is found to be 1.30 as against 1.05 per cent., and wrist flexion 1.90 against 1.35 per cent. in favor of woman. This is readily explained by the constant small movements in sewing, knitting, etc., which form a large part of woman's occupation. Piano

TABLE 3.—PERCENTAGES IN HIP AND KNEE EXTENSIONS AND FLEXIONS

	Hip Extension Per Cent.	Hip Flexion Per Cent.	Knee Extension Per Cent.	Knee Flexion Per Cent.
Men	3.70	3.20	3.30	1.75
Women	3.42	2.69	3.175	1.30

playing also is probably more frequent among women than among men.

The result of difference in use is especially well illustrated in a brief consideration of dorsal flexion. Children between 5 and 16 years of age show 3.20 per cent., women 3.07 per cent., and men 2.85 per cent. of their total strength. Strapping the foot to the stiff unyielding sole of modern shoes might account for the falling off in power of these muscles in the adult. That woman has considerably more power than man may be due to the fact that she is more commonly trained in dancing, as was the case in this series of college women as compared with college men.

Inversion shows little difference between men and women, the percentages being 1.90 for men and 1.95 for women. Eversion makes 1.80 per cent. of the total strength in man and 1.935 in woman. Again the fact that a large percentage of these women had some training in esthetic dancing may be a factor in the difference.

Adduction is responsible for 1.60 per cent. in man and 1.68 per cent. in woman. This may possibly be

influenced by the conventional requirement of ladylike behavior, which demands that a woman's knees be kept together.

Abduction causes little difference, being 1.50 per cent. of man's total strength and 1.475 per cent. of woman's.

The most striking difference is found in the hip and knee extensions and flexions, shown in Table 3.

The limitation of movement due to the skirt and the consequent limitation of activities will probably fully account for this difference. A superficial comparative study of Case 41, who grew up in overalls until she was 12 years old, having the same activities as her brother, may be profitable in discussing this point. Results of the comparison may be observed in Table 4.

Case 41, although a most perfect feminine type, shows only slight variation from her brother in hip extensions and flexions, considered either in pounds

TABLE 4.—COMPARISON OF CASE 41 AND HER BROTHER

	Hip		Hip		Knee		Knee	
	Extension Lb.	Extension %	Flexion Lb.	Flexion %	Extension Lb.	Extension %	Flexion Lb.	Flexion %
Case 41	155	4.41	95	2.85	113	3.21	50.5	1.43
Brother 14 months older.	159	4.41	102	2.80	113	3.14	62	1.72

or in percentage distribution. She has worn skirts only four years.

The effect of the limitation of skirts is well illustrated in Case 37, whose extensions and flexions are considered in Table 5. Here we have a woman more than 50 years old who has used a bicycle over a long period of years, often riding as many as 3,000 miles in a single year. We find her hip and knee extensors with a percentage distribution of her total strength exceeding the men athletes, while because of the limitation of skirts extending over a great many years, hip and knee flexors show a percentage distribution falling considerably below the percentage distribution in the group of college women who belong to a later period, when the limitation of skirts is less continuously operative. This case emphasizes the effect of use or disuse as a determining factor.

From this hasty survey of the data concerning the muscular strength of college women, certain tentative conclusions are suggested:

There is no difference in the muscular strength of women and men which is due to sex as such. Such differences as are frequently found are due to differences in the use of the muscles, brought about by the conventional limitations of activity or by dress. Marked overweight or marked underweight tends to lower the strength factor, as does also lack of coordination, which is too frequently found in women and exaggerated by their scant physical activity in childhood. The effects of muscular training persist long

TABLE 5.—PERCENTAGES IN A COMPARATIVE STUDY OF HIP AND KNEE FLEXIONS AND EXTENSIONS

	Hip Extension Per Cent.	Hip Flexion Per Cent.	Knee Extension Per Cent.	Knee Flexion Per Cent.
Case 37 (age 53 $\frac{3}{12}$ years)	3.93	2.425	3.61	1.195
Average percentage athletic men	3.70	3.20	3.30	1.75
Average percentage women	3.42	2.69	3.175	1.30

after the particular exercise has ceased. A high degree of muscular power in a woman in no way lessens her racial efficiency. Lack of muscular power, as in the pectoral muscles, may be a distinct racial disability.

It has been shown that periodic disability in a woman when no organic disease exists is readily eliminated.⁵ We may therefore conclude that sex is not necessarily a disability, and that if some method be found of adjusting work to the individual strength under proper hygienic conditions, without reference to sex, there is no reason why the potential power of woman may not be used without danger of lessening her racial efficiency.

5. Mosher, C. D.: A Physiologic Treatment of Congestive Dysmenorrhea and Kindred Disorders Associated with Menstrual Function, THE JOURNAL A. M. A., April 25, 1914, pp. 1297-1301; Health and the Woman Movement, National Board Y. W. C. A., 1915.

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